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| FORM PTO-1390<br>(REV. 9-2001)   |  | U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | ATTORNEY'S DOCKET NUMBER<br>194-15537-WO-US                                     |
| TRANSMITTAL LETTER TO THE UNITED STATES<br>DESIGNATED/ELECTED OFFICE (DO/EO/US)<br>CONCERNING A FILING UNDER 35 U.S.C. 371   |  |   | U.S. APPLICATION NO. (If known, see 37 CFR 1.5<br>60/140,248 <b>10/009888</b> ) |
| INTERNATIONAL APPLICATION NO.<br>PCT/US00/16835  | INTERNATIONAL FILING DATE<br>June 19, 2000 | PRIORITY DATE CLAIMED<br>June 18, 1999                  |   |
| TITLE OF INVENTION<br>Sequential Disinfectant Treatment for Waste Water  |  |   |   |
| APPLICANT(S) FOR DO/EO/US<br>Baker Hughes Incorporated   |  |   |   |
| Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:  |  |   |   |
| <p>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</p> <p>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</p> <p>3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.</p> <p>4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31).</p> <p>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))</p> <p>a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</p> <p>b. <input type="checkbox"/> has been communicated by the International Bureau.</p> <p>c. <input checked="" type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</p> <p>6. <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</p> <p>a. <input type="checkbox"/> is attached hereto.</p> <p>b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4).</p> <p>7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))</p> <p>a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</p> <p>b. <input checked="" type="checkbox"/> have been communicated by the International Bureau.</p> <p>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</p> <p>d. <input type="checkbox"/> have not been made and will not be made.</p> <p>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).</p> <p>9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</p> <p>10. <input type="checkbox"/> An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</p> <p><b>Items 11 to 20 below concern document(s) or information included:</b></p> <p>11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</p> <p>12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</p> <p>13. <input type="checkbox"/> A <b>FIRST</b> preliminary amendment.</p> <p>14. <input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment.</p> <p>15. <input type="checkbox"/> A substitute specification.</p> <p>16. <input checked="" type="checkbox"/> A change of power of attorney and/or address letter.</p> <p>17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.</p> <p>18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).</p> <p>19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).</p> <p>20. <input type="checkbox"/> Other items or information:</p> |  |   |   |

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**SEQUENTIAL DISINFECTANT TREATMENT FOR WASTE WATER**

The present invention relates generally to a method and apparatus for treating waste water and, more specifically, to a method and apparatus for treating wastewater to reduce bacterial contamination thereof through sequential dosing of a stream or column of waste water with a single disinfectant agent such as chlorine.

Pollution attributable to the discharge of waste water into bodies of water such as rivers, lakes, estuaries and larger bodies of water has long been recognized as a significant public health problem due to the presence therein of bacterial and viral microorganisms posing threats to humans and other animal life. Untreated waste water typically carries fecal material, which includes coliform bacteria, posing a significant health risk. Chlorination is a well known method of treating waste water to reduce the levels of bacterial and viral microorganisms to recognized, acceptably low levels. Dissolution of chlorine in water forms a mixture of hypochlorous (HClO) and hydrochloric (HCl) acids. The latter completely dissociates into hydrogen and chlorine ions, while the former only partially dissociates into hydrogen and hypochlorite ions, relating to the pH of the water. In either case, the chlorine effectively destroys and suppresses the bacterial and viral microorganisms present in the wastewater.

Chlorine also, unfortunately, reacts with other substances typically contained in waste water to form, over time, other compounds. For example, chlorine reacts with ammonia to form chloramines. Thus, over time, chlorine is depleted from the waste water or, stated another way, chlorine demand is time-

dependent. The amount of active chlorine present in waste water at any given time is referred to in the art as the "free chlorine residual", or merely the "residual". Residual may be determined as the difference between the demand to the time of determination and the total chlorine dosage introduced into the waste water.

In stage one sewage treatment plants, a common method of disinfecting waste water is by injecting gaseous and/or liquid chlorine into that water as it enters a "contact tank". In such a disinfection process, it is important to provide a sufficient dose of chlorine to 'contact' a body of flowing waste water effluent for a sufficient period of "contact time" to effect disinfection of the water to an acceptably low level of contamination. The dosage and contact time must be sufficient to achieve the desired level of disinfection without a large excess of residual chlorine in the treated water. For example, a typical public health standard may require disinfection of the waste water so that there are no more than 5000 coliform colonies per milliliter ("cfu/ml") in the treated water with a residual chlorine level of about 0.1 part per million (ppm).

A typical design for a "contact tank" is shown in Figures 1 and 2. In such a contact tank, the waste water is disinfected by providing an initial, single dose of chlorine to the water as it enters the contact tank. As shown in Figure 2, the chlorine is typically injected throughout, or across the cross-sectional area of, a moving waste water column entering the contact tank at a single dosing location. This dose of chlorine is carried with the water in plug flow fashion and disinfects that water as it passes through the tank. A typical problem with such a single dosage disinfection process is that chlorine has a short half-life in water. Thus,

the initial dosage of chlorine must be carefully selected to be of sufficient magnitude to ensure that the free chlorine residual will be sufficient during the time of passage through the contact tank to disinfect the water to a desired low level of contaminants without an unacceptable residual chlorine level remaining at the end of the treatment process.

A significant problem with the traditional, single point dosage chlorination process is attributable to application of chlorine only at the entrance to the contact tank, as it is very difficult to accurately judge the proper, single chlorine dose to be added to the waste water. The proper dosage must be adjusted according to the bacterial loading and inherent organic chlorine demand of the waste water, as well as the amount of effluent in that waste water. An additional problem is due to the extended residence time of each portion of the flow of waste water in the contact tank, typically about 30 minutes for a tank about 70 meters long. Because chlorine is injected into the waste water at a single point, the aforementioned "plug flow" results. As each "plug" or segment of waste water flows through the contact tank, the chlorine reacts with the inherent organic material and bacteria in the surrounding waste water and with any effluent in that waste water. Those reactions reduce the free chlorine residual available for treatment of the harmful microorganisms and may, in some circumstances, reduce the free chlorine residual to a level insufficient for effective treatment. Thus, the proper single chlorine dosage at the contact tank entrance must be varied to accommodate flow rate, the length of the flow path through the contact tank, bacterial and viral contaminant loading (bacterial loading usually being used as the standard), the concentration of effluent in the waste water, and the inherent chlorine demand

attributable to organics in the waste water. Failure to regulate the chlorine dosage properly may result in either an unacceptably high level of microorganism colonies at the end of the treatment process or an unacceptably high residual chlorine level. As the former result is more undesirable, the conventional approach is to introduce an excessive chlorine dose, resulting in excessive residual chlorine but at least complying with the requisite public health standards. However, such an approach requires a relatively larger chlorine generation capacity, with attendant larger capital and operating expenses.

Finally, as previously noted, chlorine exhibits a short half-life. Thus, using the plug flow of waste water to "carry" a single chlorine dose along full length of the flow path through the contact tank for the extended tank residence time is inefficient due to the resulting deterioration of the chlorine concentration.

The problems associated with single dosage processes are further compounded by variations in the composition of the waste water. This can be particularly true in Hong Kong and other locales where the entire sewage system utilizes sea water or another water source exhibiting highly variable bacterial loading and organic content. Because sea water has exceptional seasonal variation in composition, including its inherent organic content and bacterial loading, the continuous attainment of both the desired bacterial count standard and the residual chlorine level standard in the treated water is very difficult. An inability to meet both standards is unacceptable where a water permit or other environmental regulation sets specific limits for both bacterial counts and residual chlorine levels.

As noted above, the typical treatment process applies a high dosage of chlorine at the single initial injection site to ensure adequate disinfection for the entire waste water flow path. However, the resulting chlorine residual in the treated water is unacceptably high from an environmental standpoint due to harm to fish and other forms of marine life, which impairs commercial harvest yields of marine life and may also have an adverse affect on fishing-dependent tourism.

Technologies other than chlorine dosage, such as ultraviolet and ozone treatments, have been developed to disinfect waste water. These alternatives are unacceptable in many locations, however, due to higher capital and operating expenses than those associated with the above-described conventional chlorination technique. Such technologies may also present safety and environmental problems not associated with the conventional chlorination technique.

#### BRIEF SUMMARY OF THE INVENTION

The present invention includes a method and apparatus for sequentially dosing waste water flowing along a path, such as in a contact tank, at multiple locations along the length of the flow path. The invention affords the advantages of administering doses of disinfectant at spaced points along the flow path such that an effective level of disinfectant is maintained throughout the length of the flow path to achieve the desired reduction in bacterial and viral microorganisms while employing a lesser total quantity of disinfectant than is required with a traditional single-dosage technique, thus providing an effective treatment process while reducing the residual chlorine level at the end of treatment.

One embodiment of the invention encompasses a method of "graded multi-point dosing" (GMPD), by which a disinfectant such as chlorine is injected at a plurality of points spaced along the length of an elongated flow path through a treatment vessel such as a contact tank. Preferably, the disinfectant may be injected into a waste water stream moving along the flow path at about the same time at the plurality of points so that an effective level of disinfectant can be maintained within the stream as it travels the flow path. The doses of disinfectant are also preferably injected proportionally, as by relative volume, at the plurality of points. The dose of disinfectant is preferably the largest at the upstream-most injection point, since the microorganism loading, concentration of effluent and inherent organic disinfectant demand in the waste water will be the highest prior to any treatment. Downstream of the first injection point, the foregoing constituents of the waste water will be relatively lesser in magnitude, requiring a lesser dosage of disinfectant to maintain an effective residual level of disinfectant. As used herein, an "effective level" of disinfectant means an effective level of disinfectant to kill or otherwise render substantially harmless at least one selected bacterial or viral microorganism present in the waste water. If more than two injection points are employed, the dosage required to be injected at the third, fourth and each subsequent injection point will usually be smaller than the dosage injected at the injection point upstream therefrom and greater than the dosage employed at an injection point downstream therefrom, such that the dosages are graded.

Another embodiment of the invention encompasses an apparatus for injecting doses of disinfectant at a plurality of spaced points along a flow path



through a vessel such as a contact tank. The apparatus is configured with an inlet for receiving a stream of waste water and at least two injectors or groups of injectors spaced at dosing locations along the flow path for injecting doses of disinfectant into the waste water stream before the stream exits the vessel at an outlet thereof. A source of disinfectant is provided, as is a conduit arrangement, which may take the form of a manifold, for delivering disinfectant from the source to the injectors. Preferably, a flow control device is associated with each injector or injector group for a single dosing location so that the dosage of disinfectant delivered into the flow path by each injector or group may be selected and varied. A controller may also be provided to initiate the flow control devices to adjust the dosage level of disinfectant delivered by each injector, and one or more sensors provided to sense conditions in the waste water at one or more locations to provide signals, responsive to which the controller may initiate the flow control devices to vary the disinfectant flow to each dosing location.

In utilizing the method and apparatus according to the invention, it is desirable to employ a dosing liquid, or diluent, as a carrier for the disinfectant from the source to the injection points, and preferably in conjunction with the previously-described GMPD technique. Using a dosing liquid and injecting disinfectant carried thereby into the waste water flow path at a plurality of points instead of employing conventional single point injection does not require an amount of disinfectant in excess of that required by the conventional technique, and in fact may be less. Instead of using the entire volume of waste water in plug flow as a transport vehicle to carry the disinfectant throughout the length of the flow path, the vehicle comprises only the far lesser volume of dosing liquid.

Because the smaller volume (usually by at least several order of magnitude) of dosing liquid transfers the disinfectant to the waste water, the inherent disinfectant demand of the dosing liquid vehicle is far less than that of the waste water stream conventionally employed. Thus, more active disinfectant may be transferred from the source to the waste water stream to effect disinfection thereof. Consequently, using GMPD, substantially less disinfectant may be employed to effectively reduce microorganism concentration (such as, for example, coliform bacteria count) while also reducing the disinfectant residual at the end of the flow path.

The apparatus of the present invention may be added to an existing waste water treatment contact tank or other vessel at a relatively nominal capital cost in comparison to that required to implement an ultraviolet or ozone disinfectant technique, and with substantially no increase in operating cost after installation, in comparison to conventional, single point disinfectant injection.

The disinfectant employed with the invention may comprise any suitable chemical agent effective for reducing the concentrations of bacterial and viral microorganisms present in the waste water to be treated. Chlorine in various forms is a preferred disinfectant, and may include, by way of example only, chlorine in liquid or gaseous form, sodium hypochlorite ( $\text{NaOCl}$ ), disinfectants including a chlorine component, and mixtures of the foregoing. Other disinfectants as known in the art and suitable for use with the multi-point injection technique according to the method and apparatus of the invention may also be employed. The disinfectant source may comprise a pressurized vessel, a vessel

from which disinfectant may be pumped, a generator to provide disinfectant in gaseous form, or other sources as known in the art.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an overhead view of a contact tank and chlorine injection line according to a prior art configuration;

Figure 2 is a cross-sectional view, taken across line 2-2 of FIG. 1, of a portion of the contact tank of FIG. 1 looking along the passageway therethrough in a direction of waste water flow;

Figure 3 is an overhead view of a first embodiment of the apparatus of the present invention; and

Figure 4 is an overhead view of a second embodiment of the apparatus of the present invention.

#### DESCRIPTION OF THE INVENTION

Referring to Figure 3, an exemplary contact tank 10 with a sinuous passageway 15 defining a flow path therethrough is depicted. Other possible configurations for contact tank 10 are, of course, readily apparent to one of ordinary skill in the art. A stream of waste water enters contact tank 10 at an inlet 20 and flows along passageway 15 as depicted by the arrows shown therein to exit contact tank 10 at outlet 25. Effluent-containing waste water may be provided from any source, such as, for example, freshwater or salt water sewage from sanitary sewers, storm water sewage (runoff), manufacturing or processing plant waste water, and agricultural waste water from farming or processing, including

without limitation animal waste from cattle feed lots and other facilities for raising, for example, pigs, chickens and other livestock. Other sources of waste water are, of course, possible.

A disinfectant, preferably chlorine, is provided from any suitable source 30. The chlorine can be, for example, gaseous chlorine, liquid chlorine or sodium hypochlorite (NaOCl). The source may be pressurized to aid the flow of disinfectant, optionally mixed with a dosing liquid, through a conduit arrangement such as manifold 35 to each of a plurality of injectors 40 in communication with passageway 15. A plurality of injectors 40 may be ganged or grouped at a given location in passageway 15 and arranged to introduce disinfectant into the waste water stream across a large portion of the cross-section thereof, such an arrangement being known the art and previously described and depicted with respect to FIG. 2

A dosing liquid may be provided from any suitable source, such as waste water or other liquid suitable for carrying chlorine. The dosing liquid can, alternatively, be fresh water and/or salt water, for example. Referring to FIG. 3, the source of dosing liquid in this instance is the waste water stream itself, a portion of which is diverted from the primary flow path through contact tank by dosing line 45, which carries the diverted flow to pump 50, disinfectant being added to the dosing liquid flow at the intake end of pump 50 in desired, substantially metered proportion controllable by a metering device, which may take the form of a valve 55. A dedicated mixing chamber may be employed to mix the disinfectant and the dosing liquid or, as shown, pump 50 may be employed as a mixing chamber.

Dosing liquid with the entrained disinfectant, or in some embodiments a liquid disinfectant alone, is carried to injectors 40 through the branches of conduit arrangement or manifold 35, each branch having associated therewith a flow control device, which may take the form of a valve 60, to regulate flow to one or more injectors fed by that particular branch. Valves 60 may be employed to regulate the amount of disinfectant, or dosing liquid carrying disinfectant, to their associated injectors, and to proportion, or grade, the relative flow of disinfectant to each injector 40. Preferably, each valve is separately controlled. While valves 60 may comprise manually operated valves, it is preferably that the valves be remotely operable valves, such as servo valves, and also preferable that a controller 65 be operably coupled to each valve 60 (and, optionally, as shown in a broken line to valve 55) so that the flow of disinfectant to each injector may be remotely, separately and, as desired, automatically regulated in response to operator input or to sensed conditions in the flow stream of waste water in passageway 15. Controller 65 may comprise, for example, a dedicated programmable logic controller, or a suitably programmed personal computer. As implied above, controller 65 may also be operably connected to one or more sensing devices 70 placed in communication with passageway 15, sensing devices 70 being used to monitor, for example, disinfectant residual, bacterial content, organic content, or other parameter or parameters having utility in determining a dosage of disinfectant required to be added to the waste water stream at the location of each injector or group of injectors 40 at each dosing location spaced along passageway 15. Sensing devices 70 are preferably placed upstream of each associated dosing location, so as to monitor the effects of the

disinfectant introduced into the flow stream at an immediately upstream dosing location. In the example shown in Figure 3, four dosing locations, designated at 1-4, are located in contact tank 10 along passageway 15. The dosing locations may be substantially equally spaced along passageway 15, as shown in FIG. 3, or non-uniform spacings may be employed. As will be appreciated by those skilled in the art, the number of dosing locations and the number of dosing outlets (e.g., injectors 40) at each dosing location may be varied according to the waste water flow rate, the desired dosage of disinfectant, the concentration of disinfectant in a dosing liquid, and the disinfectant demand of the waste water flow. The injectors 40 at each dosing location are preferably positioned to effectively disperse the disinfectant into the waste water across the entire cross section of passageway 15 at the dosing location. It is also contemplated that mixing devices may be employed at the dosing locations to effect more rapid dispersion of the disinfectant into the waste water stream.

Referring to FIG. 4 of the drawings, a second embodiment of the apparatus of the present invention is depicted. Elements of the second embodiment which correspond to those described with respect to the first embodiment are, for clarity, identified by the same reference numerals. In addition to the elements of the first embodiment, the second embodiment includes one or more pretreatment tanks or units 90, which may be used to remove large solids, including particulates, from the waste water stream prior to treatment in contact tank 10. Known techniques for such removal include screening, settling, and filtration. Such pretreatment tanks 90 may enhance the effectiveness of the treatment in contact tank 10 by reducing the presence of microorganism-carrying solid waste and providing a

more easily-treatable waste water stream devoid of materials which, over time, would otherwise accumulate in passageway 15, coat, clog or even damage injectors 40, and inhibit dispersion of disinfectant into the waste water stream. One or more post-treatment tanks or units 100 may also be employed to receive waste water discharged from outlet 25 of contact tank 10. For example, a tank 100 may comprise a settling tank.

The following example illustrates aspects of the invention, although the invention is not limited by or to this example. A flow of 500 cubic meters per hour of waste water is introduced into a 70 meter (passageway length) contact tank. A chlorine dose of about 10 kilograms per hour is entrained in a dosing liquid flow of about 3.6 cubic meters per hour. The dosing liquid can be fresh water or salt water. The chlorine-containing dose flow is introduced proportionally (by volume) and at the same time, to the waste water stream at a plurality of (in this example, four) dosing locations along the passageway length of the contact tank. In this example, the 3.6 cubic meter per hour dose flow, containing 10 kilogram per hour of chlorine, is proportionally introduced into the waste water stream by GMPD at the various dosing locations. Referring to the following Table 1 in conjunction with the dosing locations shown in FIGS. 3 and 4, about 50% of the dosing liquid is introduced at Location 1, about 28% of the dosing liquid is introduced at Location 2, about 14% of the dosing liquid is introduced at Location 3, and about 8% of the dosing liquid is introduced at Location 4. As also noted, a fifth dosing location may also be employed, the use of which would, of course, cause the percentages of dosing liquid introduced at the other dosing locations to vary. Optionally, a Location 5 may only be used intermittently, such as where sensing

devices are employed in passageway 15 and detect particularly troublesome remaining microorganism concentrations after the waste water stream passes Locations 1-4. The effect of each of these disinfectant doses, as to the reduction in coliform counts and the residual chlorine levels, is monitored by taking regular samples of waste water at the end of the 'leg' of the tank down stream from the dosing location. Coliform counts are determined by a traditional agar plate assay. Residual chlorine levels can be monitored using the standard DPD colorimetric assay or by an amperometric method. Over the period of the trial, the concentration of chlorine in the dose flow can be varied as well as the flow volume itself. As will be appreciated by those of skill in the art, the assay techniques used to determine coliform counts and residual chlorine levels allow the GMPD technique to be optimized for the contact tank and waste water conditions.

Table 1. Exemplary Dosing Liquid Proportions

| Dosage Location | Approximate Percentage of Total Dosing Liquid |
|-----------------|---|
| 1               | 50%   |
| 2               | 28%   |
| 3               | 14%   |
| 4               | 8%  |
| 5               | variable                                      |

Having thus described the invention, it is to be understood that the invention is not to be limited by particular details set forth in the above description or in the claims, as many apparent variations thereof are possible without departing from the spirit or scope thereof.



**CLAIMS**

I claim:

1. An apparatus for disinfection of waste water, comprising:
  - an elongated passageway;
  - at least two injection devices respectively located at spaced dosing locations along the passageway for introduction of a disinfectant to a stream of waste water flowing through the passageway;
  - a source of disinfectant;
  - a conduit arrangement extending between the disinfectant source and each of the dosing locations; and
  - an adjustable flow control device positioned to regulate flow of disinfectant to each of the at least two injection devices through a conduit of the conduit arrangement.
2. The apparatus of claim 1, wherein said disinfectant comprises, at least in part, chlorine.
3. The apparatus of claim 1, wherein said passageway is defined within a contact tank.
4. The apparatus of claim 1, further comprising a controller operably coupled to each of the flow control devices to initiate adjustment of a regulated flow of disinfectant to each of the at least two injection devices.
5. The apparatus of claim 4, further comprising at least one sensor device positioned in the passageway and configured to sense at least one parameter usable for determining a desirable flow of disinfectant into the waste water, the at least one sensor device being operably coupled to the controller, the controller

being programmed to initiate adjustment of at least one of the flow control devices to vary a flow of disinfectant therethrough responsive at least in part to an output signal from the at least one sensor device.

6. The apparatus of claim 4, wherein the controller is configured to initiate adjustment of at least one of the flow control devices to vary a flow of disinfectant therethrough responsive at least in part to a flow rate of the waste water stream and a disinfectant demand of the waste water stream proximate at least one dosing location.

7. The apparatus of claim 1, wherein the plurality of injection devices is in excess of two injection devices.

8. The apparatus of claim 7, wherein the dosing locations are spaced at substantially equal intervals.

9. The apparatus of claim 1, wherein each of the injection devices comprises a group of injectors fed by a single conduit of the conduit arrangement.

10. The apparatus of claim 1, further including a source of dosing liquid in communication with the source of disinfectant.

11. The apparatus of claim 1, further comprising at least one pretreatment unit upstream of the passageway, the at least one pretreatment unit being operable to treat the waste water stream to enhance the effectiveness of the disinfectant.

12. The apparatus of claim 1, further including at least one post-treatment unit positioned downstream of the passageway, the at least one post-treatment unit being operable to further treat the wastewater discharged from the passageway.

13. A method of disinfection of waste water, comprising:  
flowing waste water along an elongated flow path;

introducing a disinfectant into the waste water at a plurality of spaced dosing locations along the flow path; and

controlling a dosage of disinfectant to each of the plurality of dosing locations wherein each dosage of disinfectant is less than a dosage of disinfectant introduced into the waste water at a dosing location upstream thereof.

14. The method of claim 13, wherein the disinfectant comprises, at least in part, chlorine.

15. The method of claim 13, wherein said flow path is defined within a contact tank.

16. The method of claim 13, further including selecting proportional dosages of disinfectant among the plurality of dosing locations such that an effective level of disinfectant is maintained along the flow path employing a total amount of disinfectant less than an amount of disinfectant required for dosing at a single location to maintain the effective level.

17. The method of claim 16, wherein selecting is based at least in part on a flow rate of the waste water and a disinfectant demand of the waste water proximate at least one dosing location.

18. The method of claim 16, further including providing a plurality of dosing locations in excess of two dosing locations.

19. The method of claim 18, further including spacing the dosing locations at substantially equal intervals along the elongated flow path.

20. The method of claim 13, further including providing a source of disinfectant and directing the disinfectant from the source to each of the plurality of dosing locations.

21. The method of claim 20, further including varying the dosage of disinfectant introduced into the waste water at at least one of the plurality of dosing locations at least in part responsive to at least one parameter sensed in the waste water.
22. The method of claim 20, further including providing a source of dosing liquid, mixing the disinfectant with the dosing liquid and carrying the disinfectant to the dosing locations using the dosing liquid.
23. The method of claim 22, further including providing the dosing liquid by diverting a portion of the waste water.
24. The method of claim 13, further comprising pretreating the waste water upstream of the first dosing location.
25. The method of claim 13, further comprising post-treating the waste water downstream from the last dosing location.

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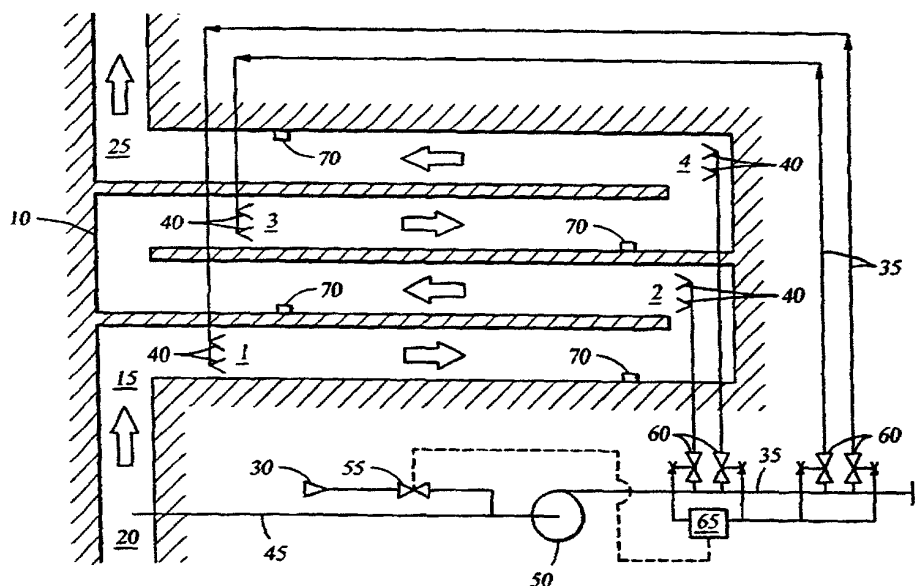
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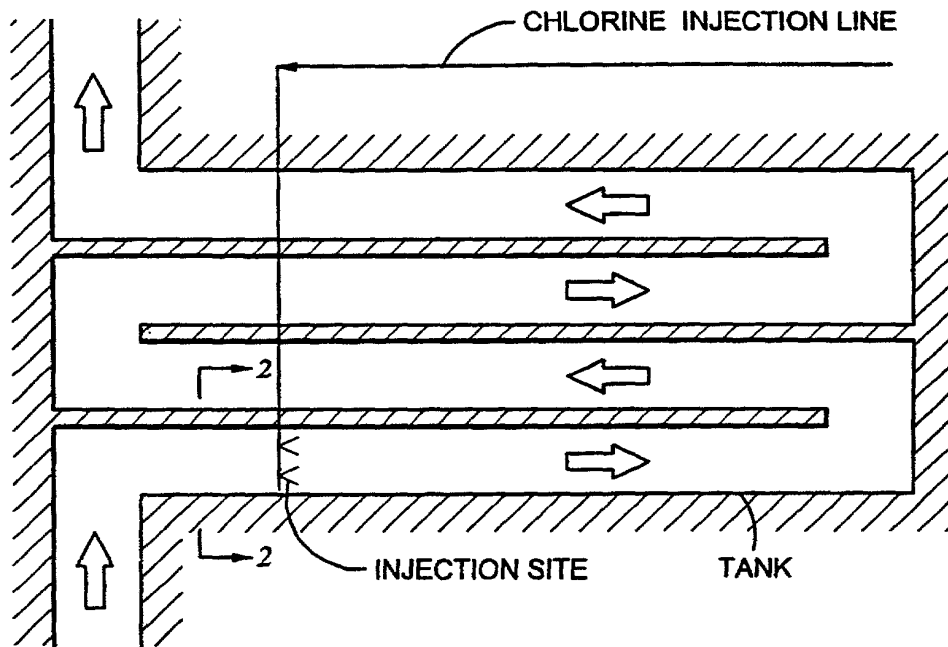
(54) Title: SEQUENTIAL DISINFECTANT TREATMENT FOR WASTE WATER



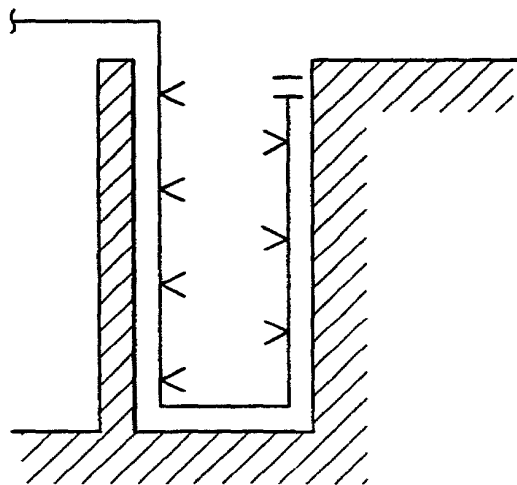
(57) Abstract: A method and apparatus for sequentially dosing waste water with a disinfectant at a plurality of spaced locations along a flow path (15), such as within a contact tank (10). Dosages of disinfectant introduced at each location are proportioned or graded such that the dosage at each location is less than the dosages delivered upstream therefrom. The graded dosing provides a level of disinfectant effective to destroy or otherwise render harmless microorganisms in the waste water and minimize the residual disinfectant remaining at the end of the flow path while employing a lesser total amount of disinfectant in comparison to conventional, single-dosage techniques.

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*Fig. 1*  
(PRIOR ART)



*Fig. 2*  
(PRIOR ART)

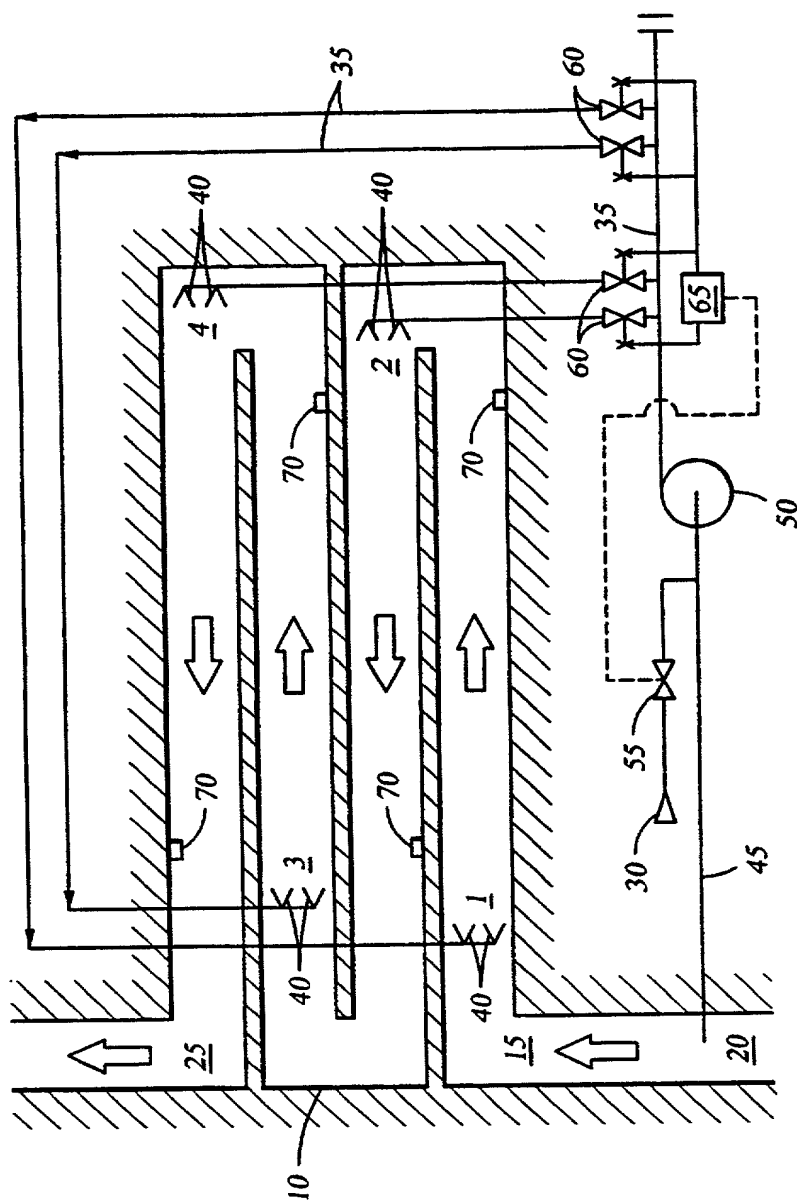


Fig. 3

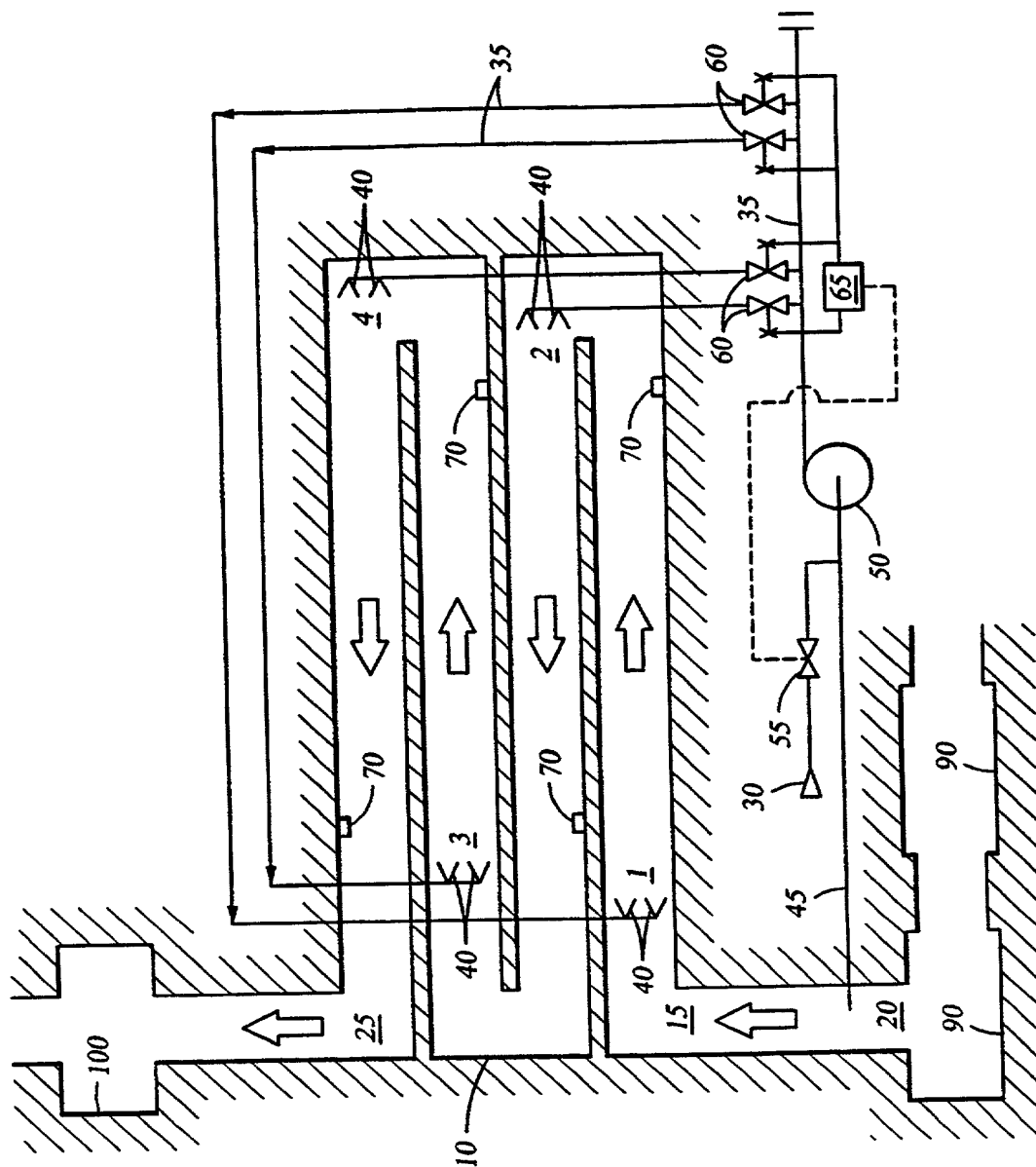


Fig. 4



**Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)**

The declaration must conform to the following standardized wording provided for in Section 214; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (iv). If this Box is not used, this sheet should not be included in the request.

**Declaration of inventorship (Rules 4.17(iv) and 51bis.1(a)(iv))  
for the purposes of the designation of the United States of America:**

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/US00/16835..... (if furnishing declaration pursuant to Rule 26ter).  
I.A. Filing Date of June 19, 2000

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications: United States Patent Application No. 60/140,248 filed on  
June 18, 1999

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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(if not contained in the request, or if declaration is corrected or added under Rule 26ter after the filing of the international application. The signature must be that of the inventor, not that of the agent)

Date: 18/06/02  
(of signature which is not contained in the request, or of the declaration that is corrected or added under Rule 26ter after the filing of the international application)

Name: .....

Residence: .....

Mailing Address: .....

Citizenship: .....

Inventor's Signature: .....

Date: .....

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".